MONTHLY WEATHER REVIEW

Editor, ALFRED J. HENRY. Assistant Editor, BURTON M. VARNEY.

VOL. 53, No. 5
W. B. No. 870

MAY, 1925

CLOSED JULY 3, 1925
ISSUED AUGUST 7, 1925

WEATHER FORECASTING AS AN AID IN PREVENTING AND CONTROLLING FOREST FIRES[1]

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[United States Weather Bureau, Washington, May, 1925]

The subject which has been assigned to me deals with a service rendered by the Weather Bureau with which the general public is only slightly acquainted. It is nevertheless one of great economic importance. It involves a number of more or less distinct phases, including the securing of meteorological and other observations, research on the basis of these, specialized forecasting, rapid and efficient communication facilities, and extensive cooperation with the Forest Service, State organizations and private forestry conservation associations.

It would require far too much time to attempt to cover the full range of the subject. Therefore, I will briefly sketch the history of the work, confining myself largely to developments in the practical side of it in the last few years.

The issuing of forecasts as an aid to the protection of forests against fires is not new. At first the regular daily forecasts were applied in the main incidentally by forestry interests in the Pacific coast States, but the advantages derived from utilizing them were so apparent that requests for a service more directly applicable to the particular purpose became very insistent, especially in the far Western States, and led to the organization of a distinctive forecast project, known as the fire-weather warning service.

The worst fires in Washington and Oregon occur in connection with the dreaded east wind. When these winds are preceded by a period of even ordinarily warm, dry weather, conditions are caused under which fires start easily; and when started, human effort, even when thoroughly organized, is taxed to the utmost in controling them. Frequently this is not accomplished until after vast areas have been devastated, many thousand dollars worth of timber destroyed, and lives sacrificed. The year 1910 was characterized by destructive forest fires in the North Pacific States, and there was a repetition in 1912. Therefore, in the spring of 1913 the Forest Service and the Western Forestry and Conservation Commission appealed to the Weather Bureau to make a special study of the meteorological conditions under which the east winds occur, with a view to forecasting them far enough in advance for preparations to be made to prevent fires by shutting down logging operations, by refraining from intentional burning of slash and débris, and by the taking of many other precautions familiar to protective agencies; also to enable the fire-fighting units to be put on guard and deployed in such way as to attack fires with the least possible delay.

The Weather Bureau was eager to render assistance to the fullest extent of its funds and facilities. However, this was by no means easy of accomplishment. No weather reports were available from certain large forested areas, especially from British Columbia. Reports from the latter region were especially important because the east winds of Washington and Oregon are caused by high-pressure areas moving across British Columbia to Alberta and Montana. Any attempt to issue fire-weather forecasts without the aid of telegraphic weather reports from British Columbia (it should be remembered that at that time observations from Alaska were not available) would indeed be a precarious undertaking. However, through the energetic interest of Sir Frederic Stupart, director of the Canadian Meteorological Service, an arrangement was made for obtaining twice-daily telegraphic weather reports from Prince Rupert, Barkerville, and Triangle Island, and by the time the season of fire hazard in 1914 arrived, a forecasting system for the States of Washington and Oregon, Idaho, and California was in operation. Forecasts for Washington and Oregon were issued by the district forecaster at Portland and for Idaho and California by the district forecaster at San Francisco. This was the beginning of what is now known as the fire-weather warning service, although it was not officially so designated until 1916.

It may interest you to know that the correspondence and negotiations in 1913 regarding organization of the service occurred in large part during the hiatus between the removal of the former chief of the Weather Bureau and the appointment of Professor Marvin to that post; and that when, shortly after his appointment, Doctor Marvin placed his indorsement on the papers approving the program for the Pacific Coast States, that indorsement contained the following significant statement:

> I think the Weather Bureau can render important service in the interest of the prevention of forest fires, and I believe the service could be extended to include any or all of the reservations more or less directly under the charge of the Forest Service, in the East as well as in the West.

The most important statement in this indorsement is that concerning extension of the work. It was not long before this was done. Under date of April 10, 1916, instructions were issued announcing the "fire-weather warnings" as a separate forecasting service. The historic importance of this announcement leads me to quote from it the following description of the scope of the service:

> District forecasters are authorized to issue warnings to be known as "fire-weather warnings" of conditions favorable for the inception and spread of fires in the forested regions of their respective districts. A careful study of these conditions, as comprehensive as practicable, especially of the wind directions as affected by the topography of the district, should be made by the district forecasters. In this study they will be assisted by the officials in charge of climatological sections, who will respond to any request for information in regard to their respective sections. Correspondence with the district foresters is also suggested in this connection.

[1] Presented before the American Meteorological Society, Washington, D. C., May 1, 1925.

Officials in charge of sections will advise the district forecasters each year as to the time when these warnings should begin and end, as determined by the condition of the timber and foliage. In the furtherance of this project stations of observation, to be equipped with such instruments as are necessary, may be established at favorable localities in the forest regions. Arrangements for the effective distribution of the warnings will be made by the officials in charge of climatological sections in cooperation with the interests to be served.

At the time these instructions were issued, officials of the Forest Service and the Weather Bureau were conferring as to a definite plan of cooperation for providing weather reports from forested areas and for determining those forests for which service was most urgent. As the details of these plans could not be completed for several months, the preliminary instructions just quoted from were issued, so that the district forecasters might render whatever service was required during the fire-hazard season then at hand. The details were completed during the summer, and on August 26, 1916, the preliminary instructions were amended, to give the names and locations of the most important forest areas subject to serious forest fires and other details. It is necessary to quote only that portion of these instructions which relates to the important features concerning the securing of weather observations from within the forests.

District forecasters will, by personal conference or by correspondence with the district forester in charge of the respective districts, endeavor to arrange for the establishment of a limited number of fire-weather warning stations, using Forest Service employees, in place as observers. The instrumental equipment of these stations will consist of an anemometer that has been fitted with a suitable device for readily obtaining the hourly velocity of the wind. Observations will be as simple as possible consistent with the needs of the service. A single daily observation of the direction and velocity of the wind, together with at least one daily dial reading of the anemometer will generally suffice.

I may say in passing that the "anemometer fitted with a suitable device for readily obtaining the hourly velocity of the wind" was devised by Mr. B. C. Kadel, chief of the instrument division of the Weather Bureau, especially for the fire-weather warning work. The purpose was to provide for inexperienced observers an instrument devoid of complicated dial readings and one that would not require the use of self-registering apparatus. The new anemometer was the now well-known "buzzer" type.

In the early summer of 1924 the conditions in the forests of California, Oregon, and Washington were unusually menacing, due to abnormal dryness, and the prospects were for a very serious fire season. In this emergency the Forest Service and forestry associations of Washington and Oregon, knowing that the Weather Bureau did not have the means for providing more service than in previous years, offered financial assistance if meteorologists were assigned to study conditions in these States and to issue localized forecasts and advices. The proposal was accepted, and meteorologists George W. Alexander and Charles I. Dague were withdrawn from other duties and assigned to the fire-weather work. Mr. Alexander was given headquarters at Seattle and charge of the work in Washington, while Mr. Dague made his headquarters at Portland and operated in Oregon. The California service was handled directly by Mr. E. H. Bowie, district forecaster at San Francisco. The cooperative arrangements provided that the salaries of the two meteorologists, telegraphic expense for weather observations from special stations located in the forests, and for the transmission of forecasts and advices to key distributing points should be borne by the Weather Bureau; and that traveling and subsistence expenses of the meteorologists while in the field, the providing of instruments at special stations, expenses incidental to the establishing and maintaining of these stations, and the distribution of the forecasts within the forests would be met by the forestry associations.

It was not possible for Messrs. Alexander and Dague to be relieved of their regular station assignments until midsummer. Arriving at their headquarters about the middle of July, 1924, they proceeded at once to organize an intensive preliminary survey of the meteorological conditions in their respective forest areas. It seemed best for forecasting purposes to divide the States into districts and subdivisions determined by forest types, topography, etc. Thus in the State of Washington two major divisions were decided on—eastern and western—and these in turn were subdivided into three and four sections, respectively. The subdivisions had more or less definite geographic bounds and were given identifying numbers which were used in the forecast messages for convenience and economy in distribution.

The instrumental equipment usually provided for cooperative stations was used at each of the substations, and in addition, sling psychrometers and anemometers were provided at some of them. The purpose was to obtain as extensive a survey of humidity conditions in the forests as was possible in the hurried circumstances under which the work was begun. Daily observations were telegraphed or telephoned from the substations to the headquarters. These reports, in conjunction with the extensive system of observations received over circuits from regular stations in the United States and Canada, were very helpful in the preparation of forecasts and advices.

The first of the fire-weather forecasts under the new arrangement was issued from Seattle on August 1, 1924, and about the same time from Portland. They were continued daily until the middle of October, when the season of fire-hazard ended.

The apprehension early in that year regarding a disastrous forest-fire season in the Western States was fully justified. In California the number of fires, the area burned over and the damage done exceeded that of any other year and the fires in Washington and Oregon were exceptionally disastrous. The following comment appeared in a Forest Service news letter under date of October 31, 1924:

The most disastrous fire season that has occurred in California in a decade was closed this month by timely fall rains. Two years of markedly deficient rainfall was the outstanding factor which brought about this critical condition. The 1924 fire record surpassed in number of fires and total area burned that of 1917, a record fire year, also one of the driest seasons ever experienced in the State.

During the period January 1 to October 20, there were 2,439 forest, brush, and grain fires in California which burned over 827,000 acres, an area greater than the State of Rhode Island, and caused an estimated loss of over $5,000,000 worth of natural resources and improved property. Thirty-two per cent of all fires were caused by lightning, and 68 per cent were due to careless acts of man. Of the man-caused fires, 38 per cent were traced to smokers, largely users of "tailor-made" cigarettes, and campers were responsible for 13 per cent, incendaries 14 per cent, brush burners 8 per cent, railroads 6 per cent, lumbering operations 4 per cent, and miscellaneous causes 17 per cent.

Out of the total of 2,439 fires, 1,890 were within or adjacent to national forests and 549 were on State or private lands. Government land burned over amounted to 365,332 acres, or less than 2 per cent of the national forest area of the State. Private and State lands burned totaled 461,668 acres. The United States Forest Service spent $920,000 on fire suppression during the season.

Outstanding features of the 1924 fire season were: Four fire fighters killed on the fire line; the occurrence of over 100 large

fires ranging from 2,000 to more than 50,000 acres in area; the closure to public use of 10,000,000 acres of national forest land, and restrictions on camping and smoking placed on several million additional acres.

It will be noted that lightning was responsible for a large percentage of the fires. Attention is invited to this fact because it is well known to the forecasters that lightning is a large factor in forest-fire causation in the Pacific Coast States. They are alert to issue warnings whenever meteorological conditions indicate the probability of thunderstorms. Such advices obviously are very important.

Humidity also is now recognized as being of special significance in connection with the starting and spread of forest fires. It is being studied perhaps more intensively than any other factor connected with the problem. Last year humidity data were included in the reports telegraphed from regular Weather Bureau stations in the far Western States and in the reports from special stations. The warning messages nearly always contained forecasts, in general terms, of expected humidity conditions. This aspect of the subject is far too extensive to be more than mentioned here. Those interested will find in the MONTHLY WEATHER REVIEW several articles relating thereto.

The accomplishment of the Weather Bureau officials in the Pacific Coast States last year (the first time that expert meteorologists were ever assigned specifically and exclusively to the problem), notwithstanding that the program had to be organized and carried out in a hurry, is best shown by quotations from officials of the forestry associations whose financial contributions made the work possible:

Mr. George C. Joy, chief fire warden, Washington Forest Fires Association, October 9, 1924:

> The forecasts were timely and accurate, and this information was of the greatest assistance to all forest agencies and logging operators in preventing fires.
>
> Upon receipt of a forecast we passed it on to our field men and to loggers, with the result that extra precautions were immediately taken to prevent fires being started. It also enabled those desiring to burn slashings to choose the most opportune time to do so. Several fires were averted through our advising owners of slashings that bad fire weather was impending and for them not to burn. In these particulars the forecasts have been of direct and specific value to all forest interests. In addition, it has aroused the interest of people generally in fire prevention, and especially has this been the case with the personnel of the forest protective agencies.
>
> We are satisfied with what has already been accomplished and feel that the money we have put into the undertaking has bought us more protection than from any other particular item of our expenditures.
>
> We think that this phase of Weather Bureau activities is of the greatest moment to forest protection, and is an aid in furthering and expediting reforestation, and we earnestly urge that the investigative work you have begun this season be continued and made permanent.

Mr. C. C. Scott, secretary, County Fire Patrol Association, October 6, 1924:

> Now that our fire season is definitely over, I want to write you briefly expressing our appreciation of the most excellent service you have rendered the fire protection agencies, and to give you some idea of how the forecasts have been received by wardens and operators in the woods.
>
> As you know, at the beginning of the season many operators and some few wardens were skeptical as to the benefit to be derived from these forecasts. In other words, their education along fire-weather lines as it applied to burning conditions had been neglected. From this season's experience I know I am safe in saying that 100 per cent of our wardens and 80 per cent of the operators in our district are absolutely sold on the fire-weather forecast.
>
> Your forecasts have been remarkably accurate. Considering the rather limited facilities for gathering your information, I don't see how you do it. A practical illustration of how the forecast works is as follows:
>
> Early on the morning of September 12 you sent me fire warning. I immediately got busy on the phone, calling wardens and operators. One operator was advised to shut down his camp or double or treble his protection organization around operation. Just after I called him at his Portland office our local warden called his camp direct and gave practically the same advice I had given the Portland office. Our advice was not acted upon and as a result fire broke out in the operation that afternoon which eventually cost $60,000 in loss of logs, equipment, and time. This operator now believes 100 per cent in fire weather forecasts.
>
> Many operators, however, have called regularly in regard to weather and have shut down their camps each time the warden has advised them of the approach of bad fire weather. The idea of special fire-weather forecasts, being a new thing, had first to be sold to the operator. I believe that our work along this line this year has been so successful that next year the operators will all be anxious to get the forecasts and when the warden advises a shut down on account of fire weather their camps will be closed tight.
>
> As far as the associations which I represent are concerned, we want this service continued next year and will do everything in our power to bring about such a continuance.

It is impracticable to go into details regarding the service, the character of the observations, the location of substations, etc. Naturally, experience indicated the advisability of certain changes if the work were continued the following season. It was hoped that appropriations might be secured to enable the Weather Bureau to place the project on a permanent basis and to provide more adequately for improvement and development. Additional funds were not secured, but the forestry associations were unwilling to allow the work to lapse. They are again providing funds whereby the work may go ahead this year under practically the same conditions as last year, with the exception of minor changes. The work this year (1925) began on April 20 and will be continued into the month of October, or until the fire danger is past.

May I now call your attention, briefly, to the similar, though less highly specialized, service rendered by our Bureau in other parts of the country.

Since 1916 forecasts have been issued each year in the interest of protection of forests, especially in Montana, Minnesota, Michigan, Colorado, and Arkansas, by the appropriate district forecasters. They are issued only during periods when the district forecasters are notified by the fire wardens that the advices are needed. Although there have been some extensions each year and a considerable increase in the number of fire wardens to whom the forecasts are furnished, the work in these States is practically on the same basis as when it began. No meteorological surveys of the forests have been made by the Weather Bureau nor have any specific studies been undertaken. In phrase and substance these fire-weather forecasts and warnings are somewhat different from the ordinary daily weather forecasts and are made applicable to the conditions existing in the specific forest areas.

Prior to 1924 very little was done in the way of issuing regularly fire-weather forecasts in the eastern and southern States comprised within the Washington forecast district, although special forecasts had been made on numerous emergency occasions. In 1924 the first organized fire-weather warning service in the Eastern States was begun in Connecticut, in cooperation with the State forest fire warden. The warnings, which include indications of expected humidity, are prepared by Mr. L. M. Tarr, in charge of the Weather Bureau office at New Haven, and are issued only when more or less prolonged periods of dry weather are indicated. They are published on the weather map issued at that station, given distribution by the Associated Press and tele-

phoned or telegraphed to a limited number of wardens who further distribute them in the threatened areas.

As a result of the accomplishments in Connecticut and the Pacific Coast States, Mr. S. T. Dana, in charge of the Northeastern Forest Experiment Station (Forest Service) at Amherst, Mass., and Mr. E. N. Munns, chief of forest investigations of the Forest Service, urged that service be extended to include the remainder of the New England States and the Adirondack section of northern New York. They recognized that the Weather Bureau could not take on this extension of its work with existing appropriations, but the Chief of Bureau agreed to inaugurate a limited service if the forestry agencies of the various States would establish meteorological stations in the forests, make telegraphic reports therefrom available for use in the forecast work, and would assume at least a portion of the expense of disseminating the forecasts to the fire wardens and patrols. This offer was accepted. The various States concerned have established some of the required substations, and others will be in operation by May 15, 1925.

The forecasts and warnings for forests in Connecticut will continue to be issued at New Haven, those for the remainder of New England from Boston, and the forecasts for the Adirondack region from Albany.

The periods during which fire hazards usually occur in New England and the Adirondacks vary materially. Therefore for forecasting purposes these areas have been divided into sections according to the fire-hazard periods. The forecasts are couched in terms designed to be as helpful as possible to the wardens in appraising the fire hazard, and in this respect they follow very closely the plan of the harvest-weather forecasts as explained in the paper on that subject published in the February, 1925, issue of the MONTHLY WEATHER REVIEW. This plan is an innovation in so far as fire-weather warnings are concerned and is intended not only to accomplish an easy understanding of the scope and meaning of the forecasts, but to indicate the degree of the forecaster's confidence in the predictions. Special attention is given to forecasts of temperature, precipitation, wind direction and force, and thunderstorms. Thunderstorm forecasts, however, will be important only as they apply to the likelihood of precipitation and scattered showers, because lightning as a cause of forest fires in New England and northern New York is a negligible factor.

Humidity may be an item of importance in evaluating fire hazards in these regions, but humidity data are so deficient that no attempt will be made to forecast this element until reliable records of sufficient quantity have been obtained. Such records are being made at all the substations and it is hoped that enough will be secured this year to warrant an analysis of them which will justify an extension of the forecasts next year to include expected relative humidity changes.

A feature of the plan is that wardens and rangers at selected places in the forests are supplied with cards on which reports are made of the character of the weather each day and the moisture condition of the forest cover. These reports are expected to be of much aid to the forecasters as a check against their forecasts, and also a basis for research looking toward improvements in the service.

Regarding the Southern States, the situation is as follows: In March of this year (1925) the Weather Bureau received a resolution passed by the Appalachian Forest Research Council at its meeting February 13, 1925, at Asheville, N. C., urging "the development of a forest fire-weather prediction service adequate to meet the needs of the Appalachian forest region and to cooperate with the forest experiment station in the forest-fire studies conducted by the station." This council, composed of representatives of State experiment stations, forestry officials, forestry associations, and large lumbering corporations, is organized to coordinate and assist in investigations and service leading to forest conservation and to the development of the timber industry in the southern Appalachian region.

Lack of funds would not admit of the organization of a fire-weather warning service for the southern Appalachian region like that conducted in the Western States or even on the less extensive scale provided for New England and northern New York; but arrangements have been made whereby each morning during periods when fire hazard exists, a representative of the Forest Service secures from the forecaster in Washington by telephone, forecasts and advices concerning the probable weather conditions for various sections of the region in question. These forecasts are then telegraphed to the fire wardens, as circumstances warrant, without expense to the Weather Bureau. By this plan an expert forester, who is well informed regarding the topography and conditions in the areas for which the forecasts are made, has the advantage of personal discussion with the forecaster. Experience will probably show that more satisfactory service and more definite instructions to the fire wardens can be given in this way than by having the wardens depend on their own interpretations of necessarily brief forecasts sent directly to them.

Cards are furnished to fire wardens in the southern Appalachian region on which they make reports of daily weather, condition of forest cover, etc., for the same purpose as that referred to in respect to the New England and northern New York services.

Forest fires occur infrequently in the Appalachian region during the winter. The periods of greatest hazard are in the spring and late fall months. The fires in the spring depend chiefly on dry leaf fuel, which causes them to spread to other combustible fuels. Few fires occur after the new vegetation develops sufficiently to check the drying of the floor cover, but they begin again in the fall when the summer vegetation and the fallen leaves become dry. The hazard continues until it is removed by fall rains or snow.

Officials of the Weather Bureau who are connected with this work realize only too well the lack of sufficient knowledge concerning many factors in the relation between weather influences and forest fires, such as the indefinite but apparently important part that humidity plays in favoring the inception of fires, and in the rapidity of their spread. They know that weather forecasting in the aid of forest conservation can not be accomplished to its fullest degree without thorough scientific investigation of the subject in all its aspects. The bureau has never had funds which could be devoted to such investigations. Repeated efforts have been made to secure them, but thus far without success. However, the forecast work that has been done, practically without additional expenditures, and under discouraging handicaps, has proved the worth of the service, has elicited the commendation of forestry interests and in some instances has actuated State and private organizations to provide funds in order that the Weather Bureau might better function in their behalf. I am optimistic that in the near future the economic value of a service which gives in a single year, or in preventing a single fire, for that matter, a return of many thousand per cent, will become so patent that funds will be made available by which the great possibilities of the fire-weather warning service may be given at least a fair chance of attainment.